



Overview of Nondestructive Evaluation Science Branch

Bill Winfree

Head Nondestructive Evaluation
Sciences Branch

Presented By Buzz Wincheski, NESB

Outline



- Branch focus and personnel
- Technology Expertise
 - Structural Health Monitoring
 - Advanced NDE/NDE Science

Nondestructive Evaluation Sciences Branch



Major Activities:

- Conducts applied and computational research focused on the development of advanced nondestructive evaluation (NDE) and integrated vehicle health monitoring (IVHM) methodologies for assuring the structural safety and reliability of aero vehicles.
- Advanced sensor development to enable improved sensitivity to structural performance properties critical to structural integrity.
- Prototype systems development for field testing of advanced NDE and Structural Health Monitoring techniques and addressing critical agency needs.

Head:	Dr. William P. Winfree
Asst. Head:	D. Michele Heath
Secretary:	Maureen Sgambelluri (<i>Tessada</i>)

- Sidney G. Allison
- Robert F. Anastasi (A)
- Dr. John H. Cantrell
- K. Elliott Cramer
- Stanton L. DeHaven
- Patricia A. Howell

- Dr. Patrick H. Johnston
- Dr. Eric I. Madaras
- Jason P. Moore
- F. Raymond Parker
- Daniel F. Perey

- W. Cy Wilson
- Dr. Russell A. Wincheski
- Dr. Phillip Williams
- Dr. Meng-Chou Wu
- Dr. W. Thomas Yost
- Joseph N. Zalameda

Rathenon: Penny A. Champine

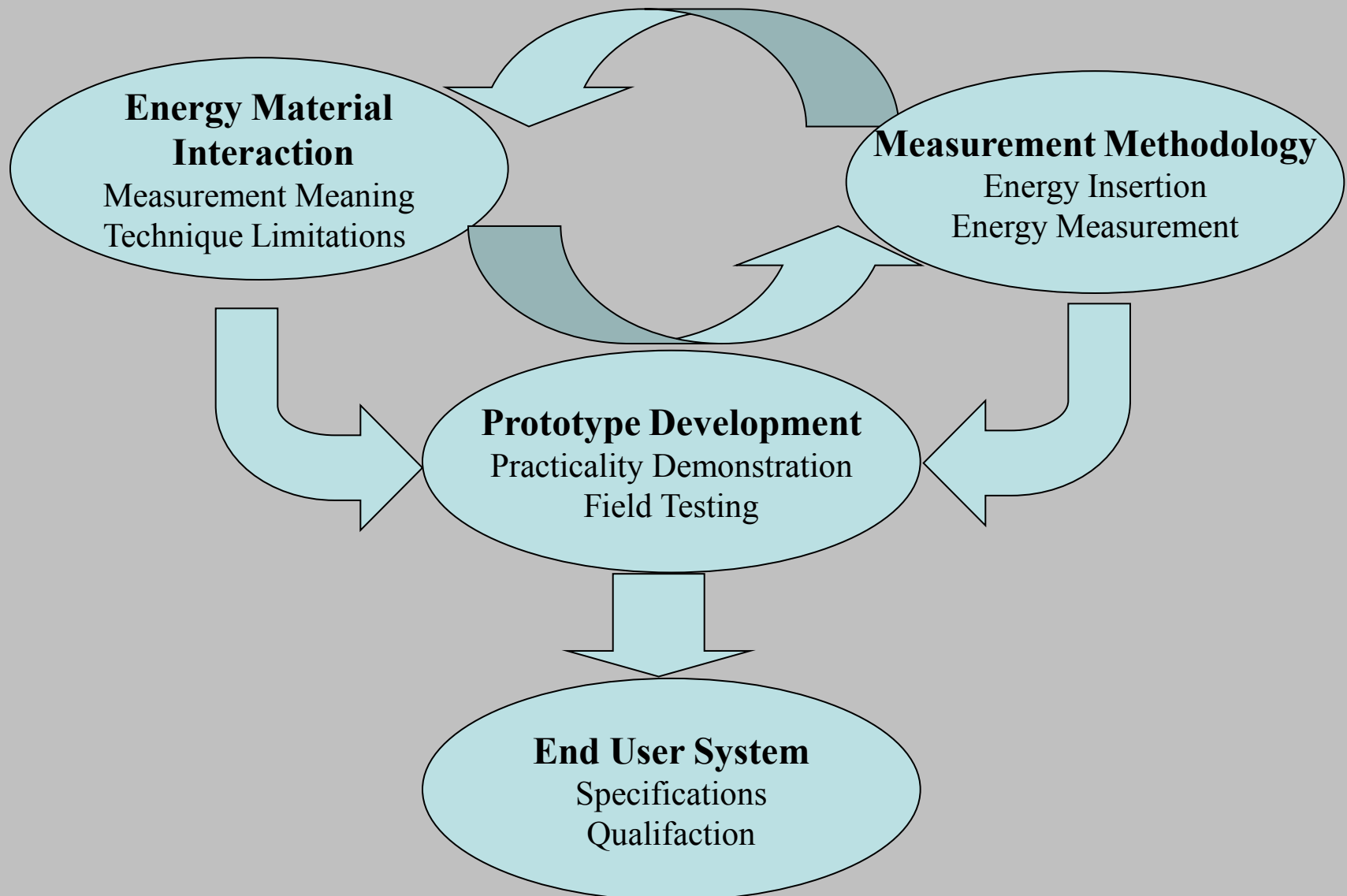
Lockheed-Martin:

- James B. Bly
- John N. Callahan

- Dr. Thomas M. Ely
- John L. Grainger

- Jeffrey P. Seebo
- John W. Simpson

Nondestructive Evaluation Sciences



Integrated Interaction Between Structural Analysis and NDE



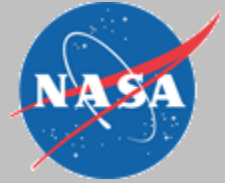
**Structural
Analysis**

Verified Prediction
Methodologies

Quantitative
Characterization

**Structural
Inspections**

**Assessment of
Residual Life
and Strength
of Structure**



Primary Programs

- Aeronautics
 - Aviation Safety
 - Aging Aircraft and Durability
 - IVHM
 - Fundamental
 - Hypersonics
- Space Operations
 - Shuttle Orbiter
 - Space Station
 - NESC
- Exploration
 - Orion
 - Ablator
 - Ares
 - Welds

**STS SRB
COMPOSITE
NOZZLE**



Eddy Current

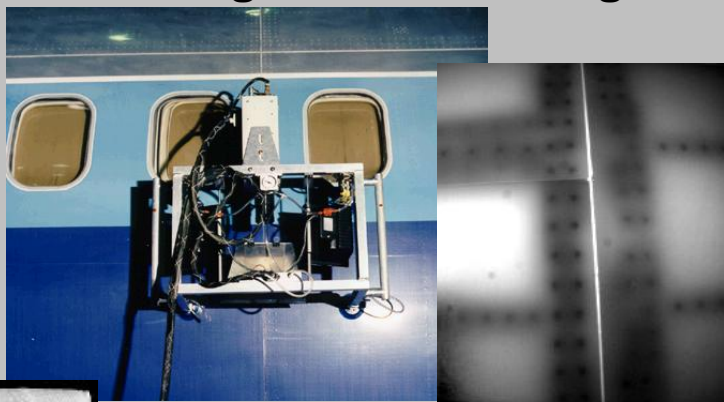
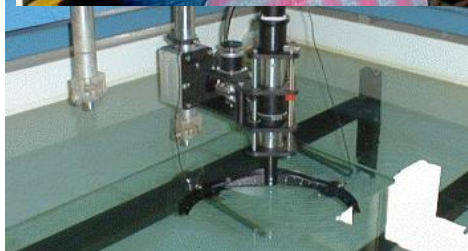


**STS SSME
COMBUSTOR
LINER**

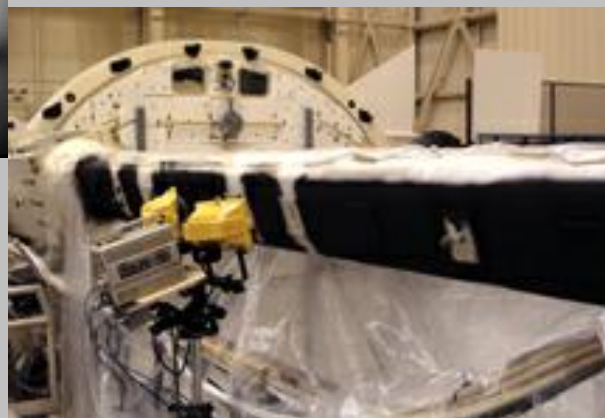


Advancing NDE Technologies for Complex Structures

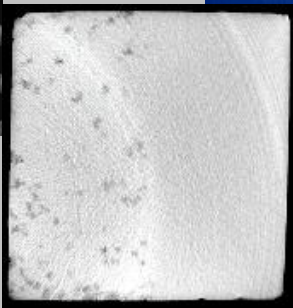
Ultrasonics



Thermal



**Orbiter
Cold Plate
Corrosion**

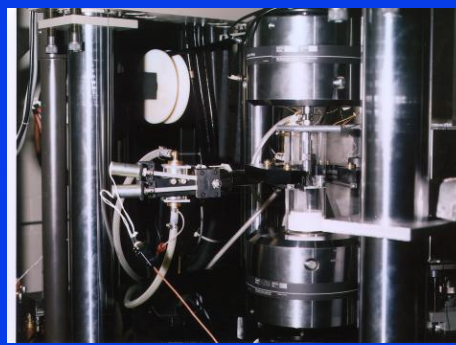


**B-757
FUSELAGE**

Computed Tomography

Manipulator Arm System

Thermal Imaging



QUEST

(Computed X-ray Tomography with Loading)

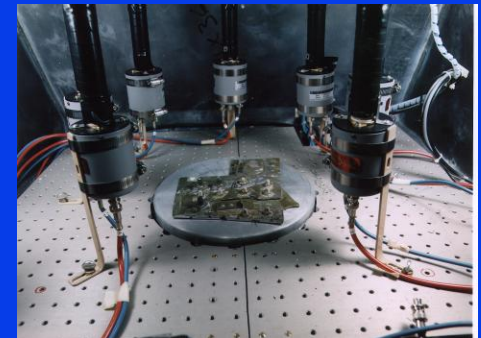
Ultrasonic Scanning



Carbon Nanotube
Sensors



Reverse Geometry X-ray



Nondestructive Evaluation Sciences Branch Major Activities

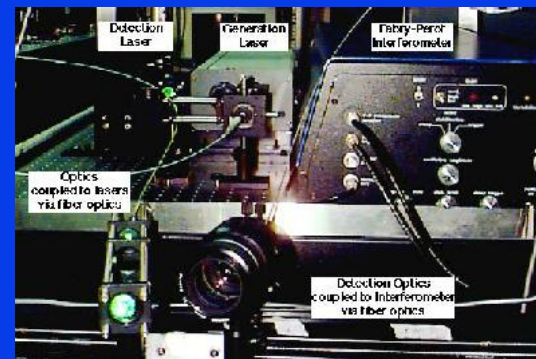
Pulsed Terahertz
Imaging



Fiber Optic Sensors



Laser Ultrasonics

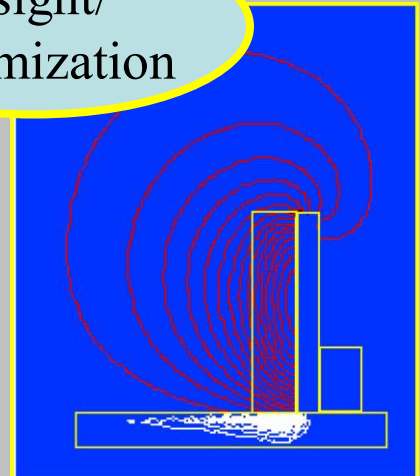
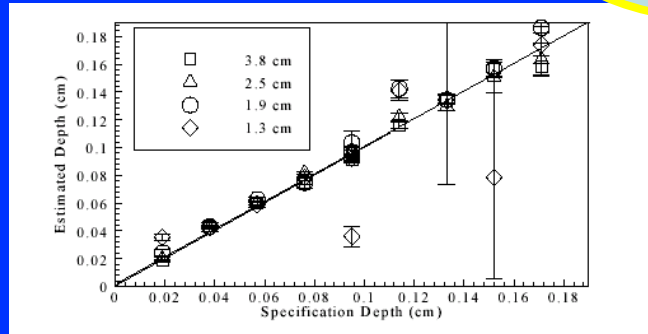
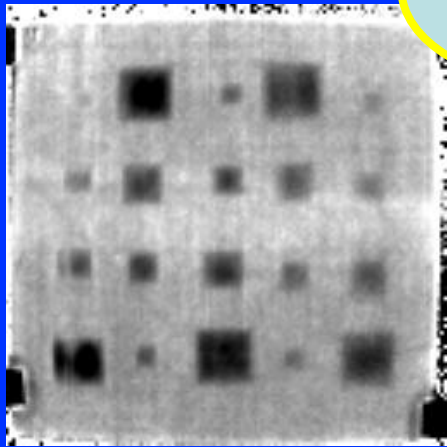
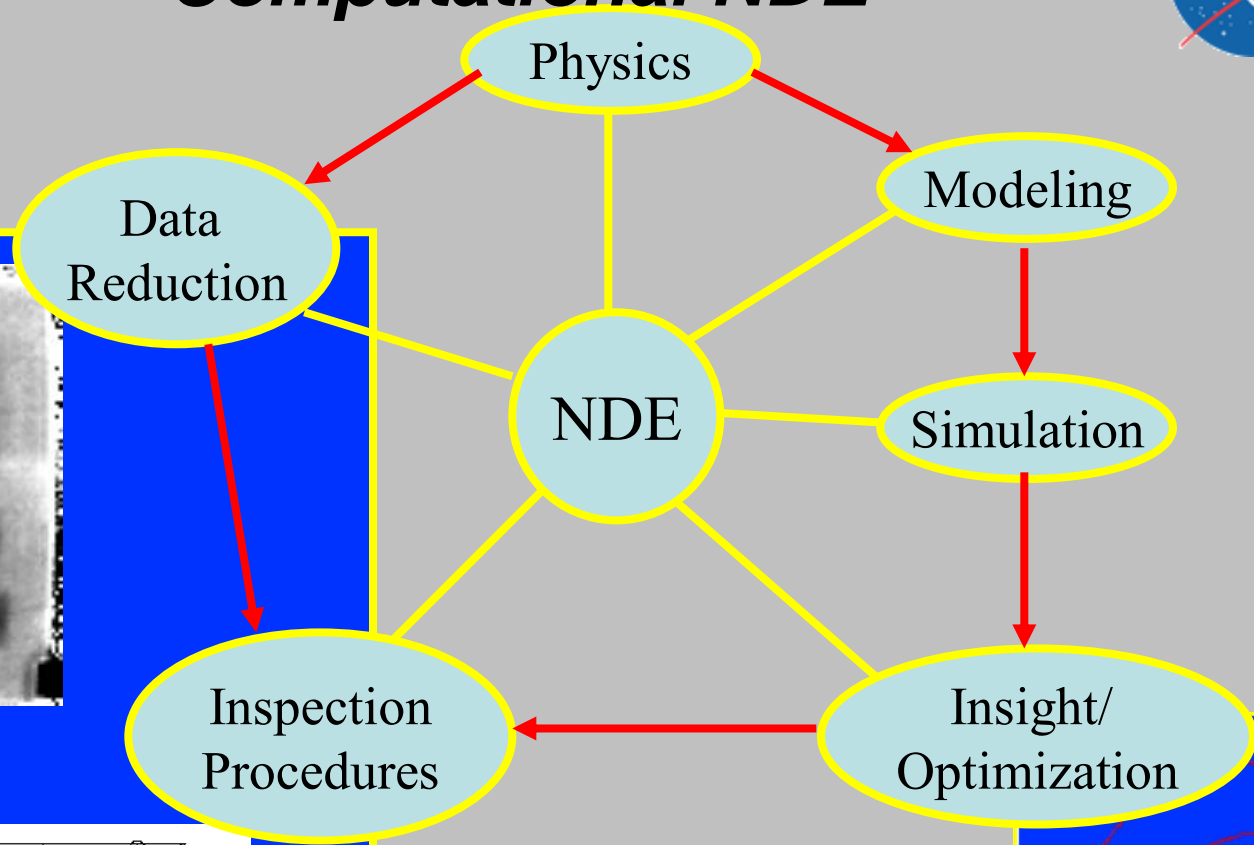


Electromagnetics

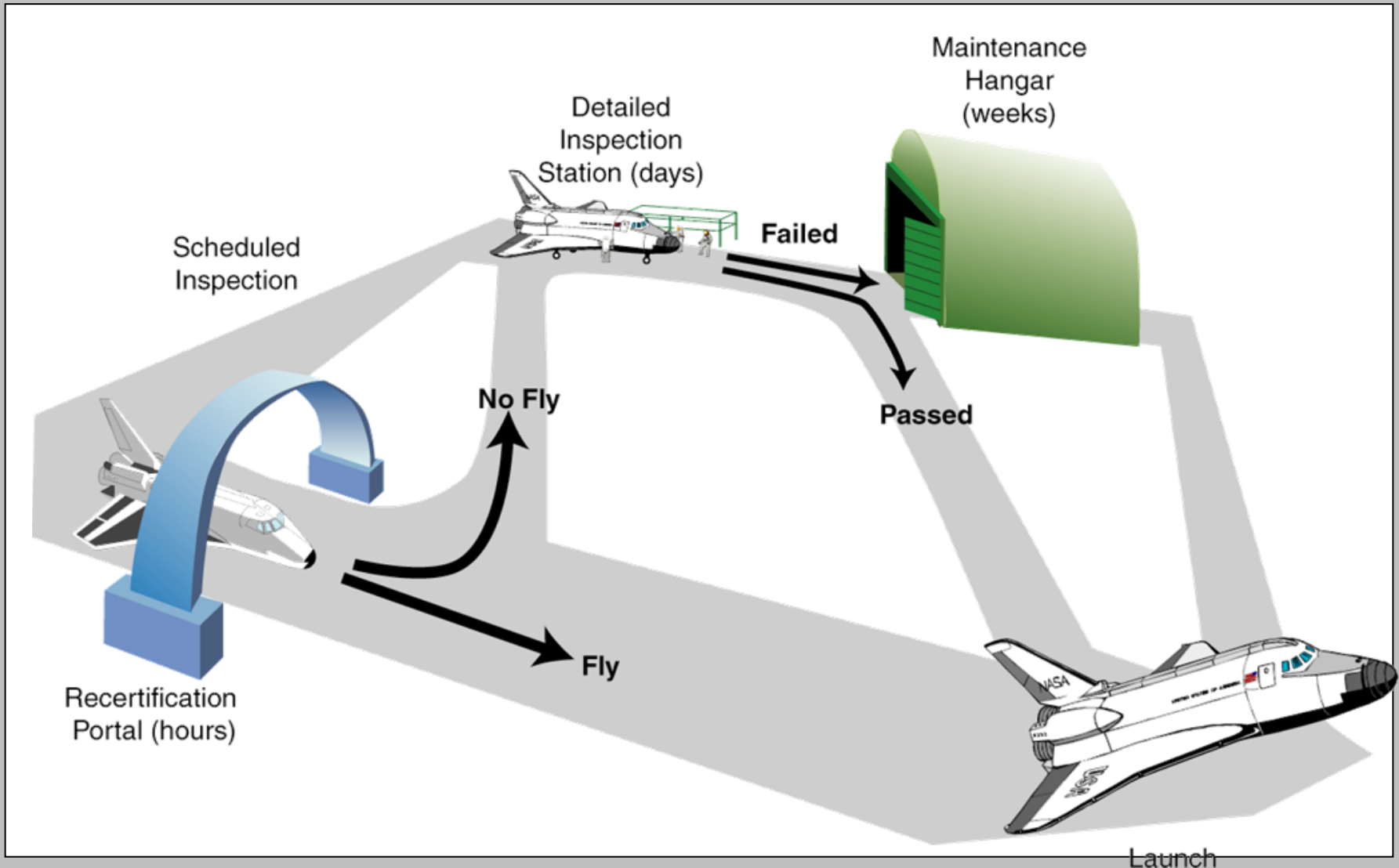




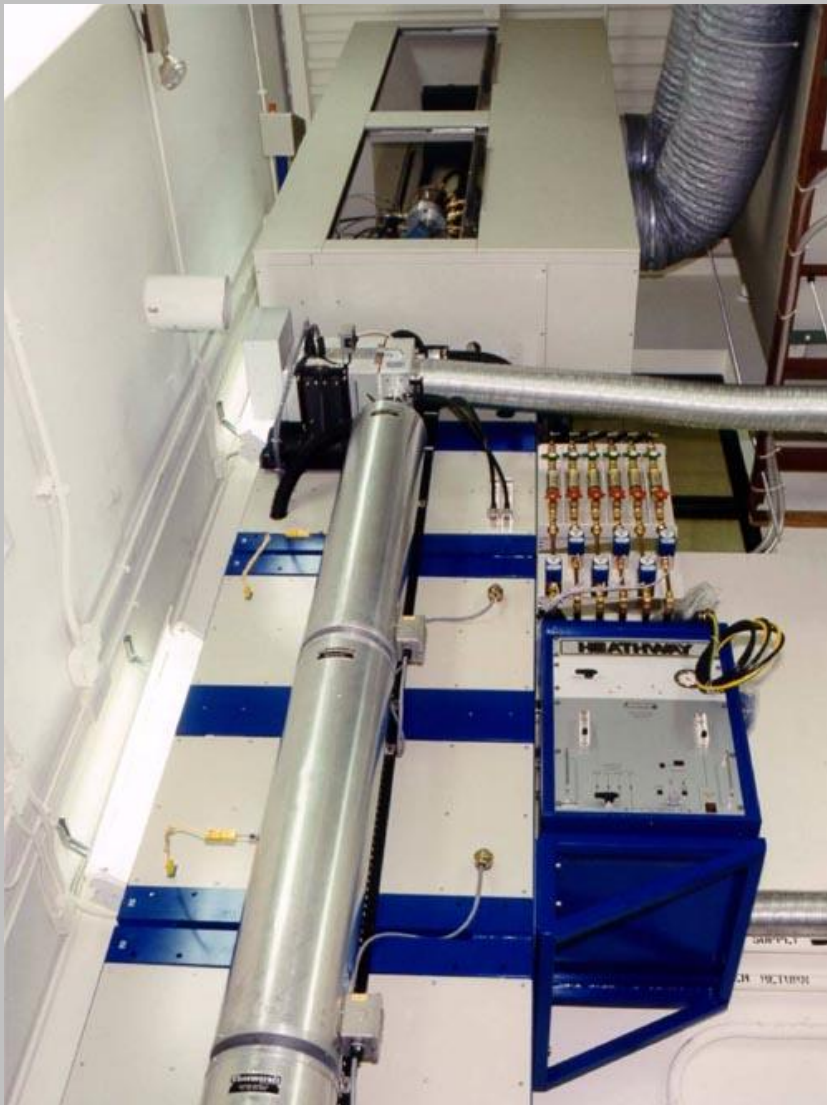
Computational NDE



Integrated Vehicle Health Management Vision

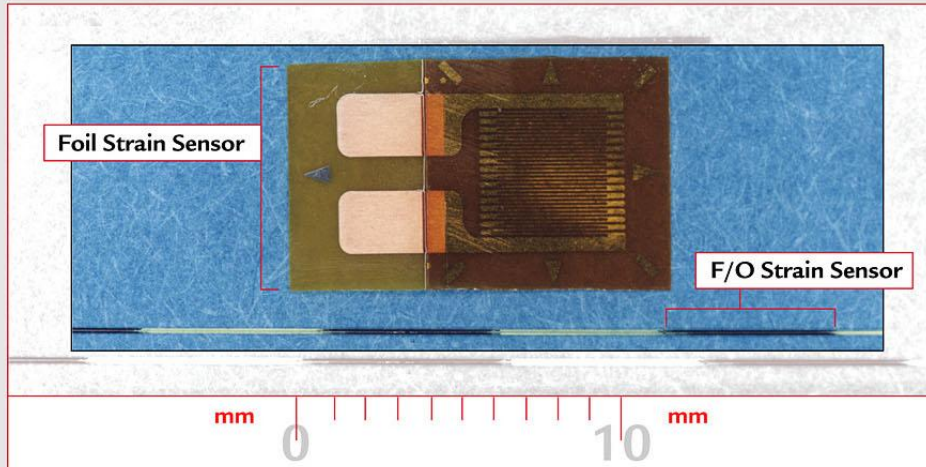


LaRC F/O DRAWTOWER



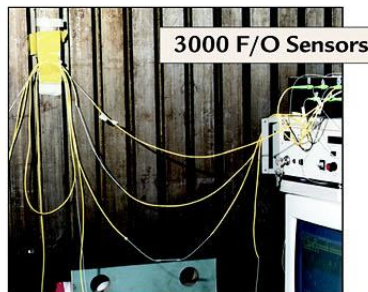
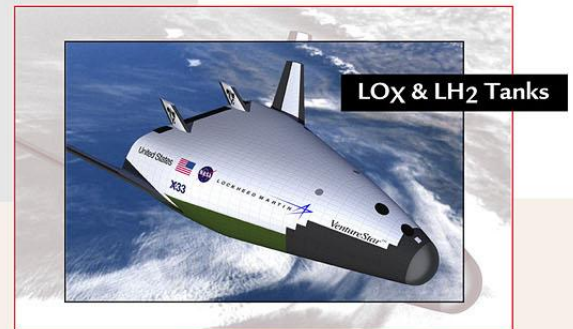
- On line sensor (grating) production
 - Custom sensor positioning
 - Increased sensor density
 - Improved fiber strength as compared to stripped/recoated fiber sensors
- Research capabilities
 - Specialty glasses and coatings
 - Fiber diameter variations
- Applications to date
 - X-33 sensors
 - Shuttle sensors
 - F-18 flight sensors
 - LaRC in-house structural test articles

Distributed Fiber-Optic (F/O) Sensing for Structures IVHM



High Density Structural Sensors

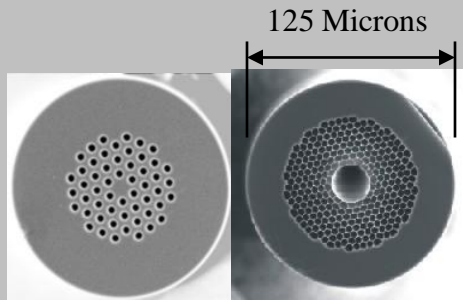
- 10,000 Sensors < 1 pound
- Strain, Temperature, & Hydrogen (Propellant Leaks)
- Future Research - Vibration, Shape, Acoustic Emission, Chemistry (Corrosion)
- < \$10/Sensor



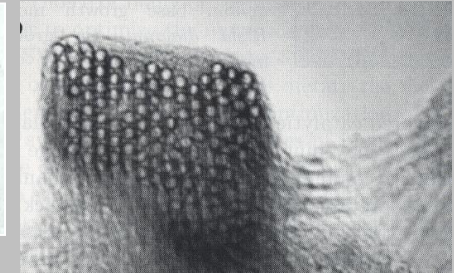
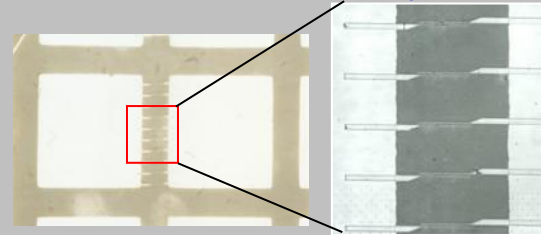
Advanced Sensing Technologies for Structural Health Monitoring



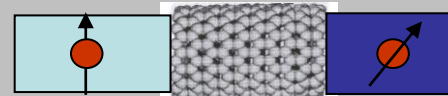
Photonic Crystal Sensing Fiber



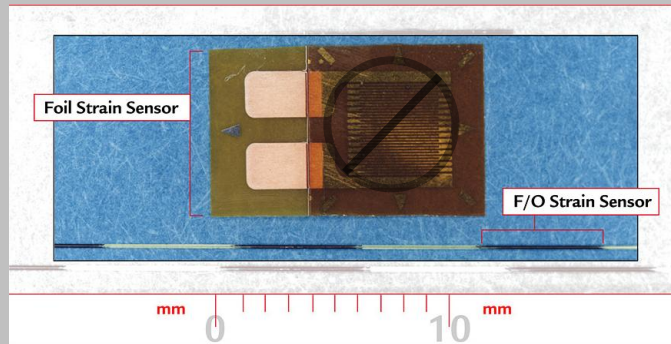
CNT based Strain Sensor Arrays



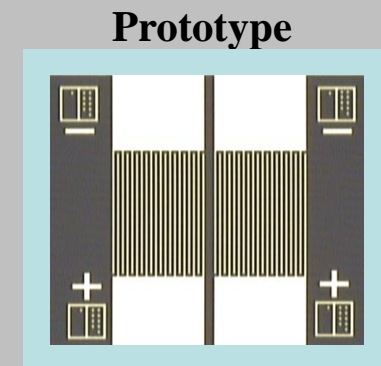
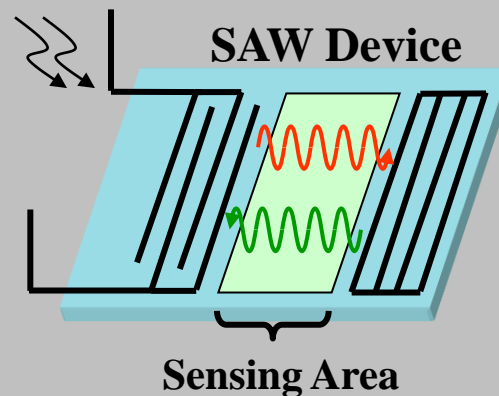
Combined Structural & Sensing material



SWCNT MTJ

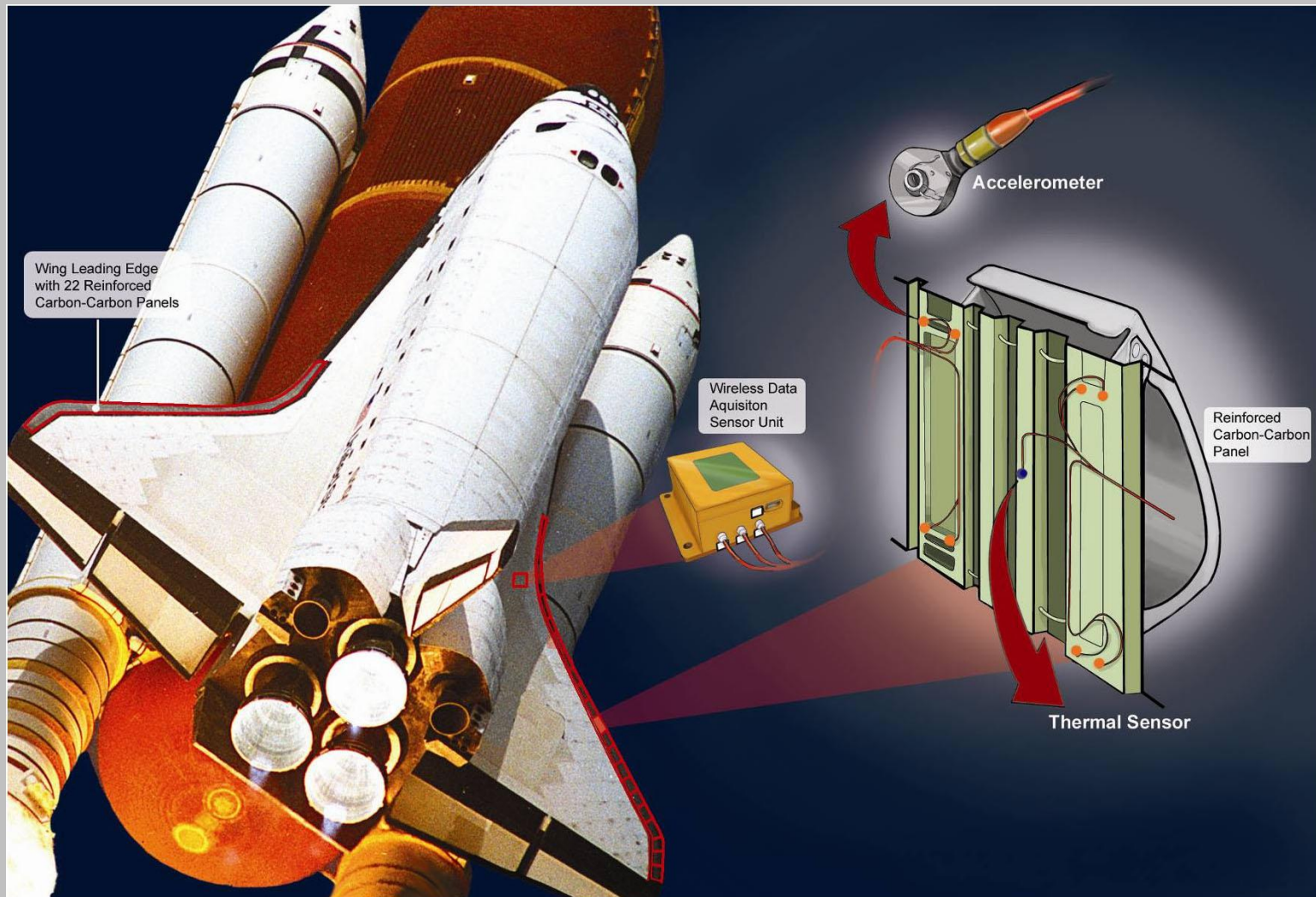


- Fiber-Bragg Grating F/O sensors
- Strain / temperature sensing
- 10,000 sensors/lb in one fiber
- Replaces foil strain sensors



- Surface Acoustic Wave (SAW) Sensors
- Strain, Temp, Pressure, Chemical, etc
- Wireless Communication and Self Powered

Space Shuttle Wing Leading Edge Impact Detection System (WLEIDS)



Introduction of NDE Technologies into NESB

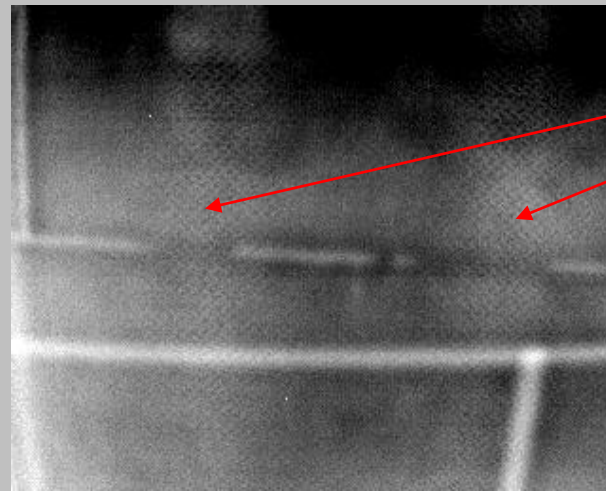


- 1980s - Aeronautics / Shuttle
 - Ultrasonics/Nonlinear Acoustics
Composites
Technology Transfer (primarily medical applications)
 - Thermography
Solid Rocket Motors
Composites
- 1990s - Aeronautics
 - Eddy Current
Aging aircraft fuselage
 - Radiography
Aging aircraft fuselage
- 2000s - Shuttle/Aeronautics/Exploration
 - Terahertz
Shuttle
 - ????

Advanced Thermographic NDE



Wing Leading Edge
Thermographic
Inspection System

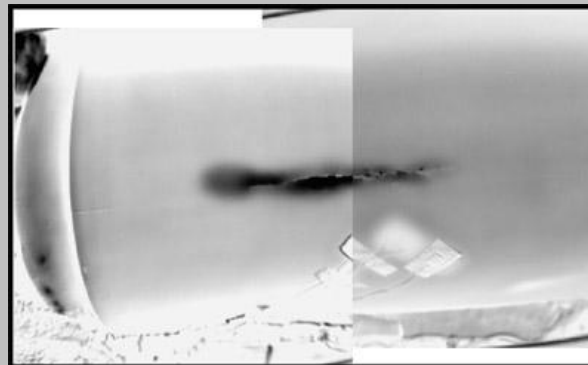


X-37

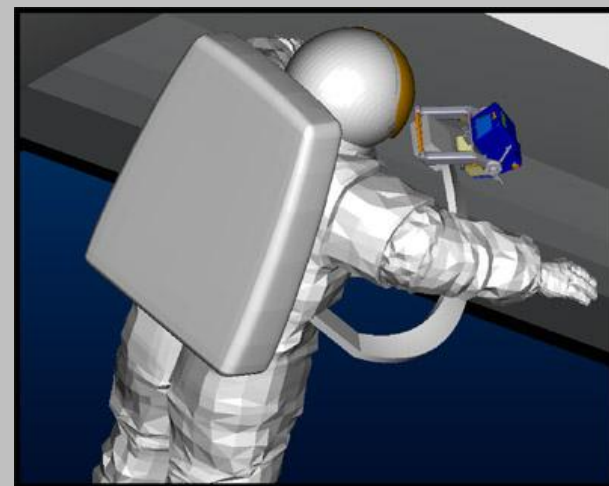
Indications of
disbonding



Thermography NDE support of
impact testing at Southwest
Research Institute(SWRI)



Thermography on an
RCC panel



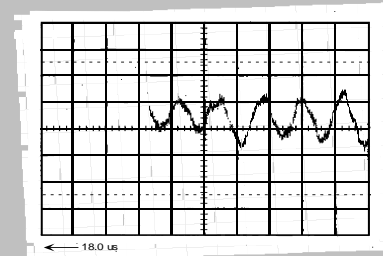
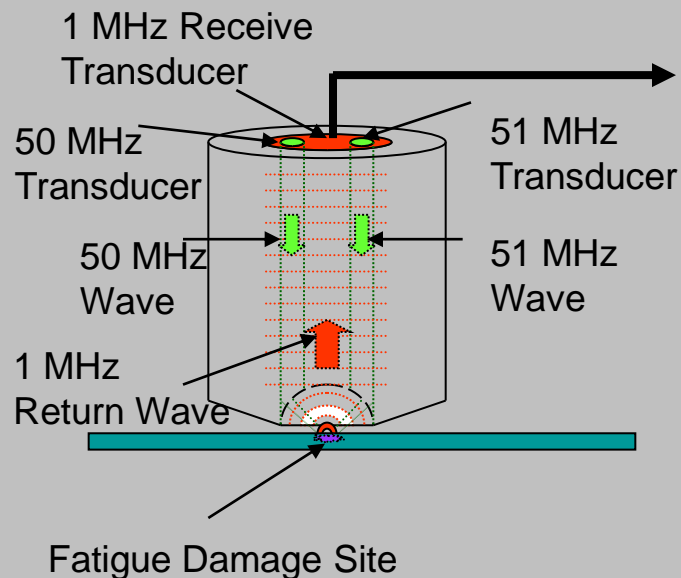
Science Base for EVA IR
Camera

Nonlinear Acoustics for Fatigue Detection

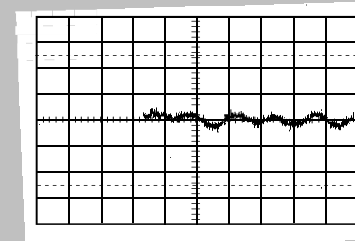


- Recent increased interest by Air Force, DARPA and Power Industry for prognostics
- Langley often cited as having done the pioneering theory and measurements in this area

Possible single sided measurement technique



Signal from Fatigue Damage Site



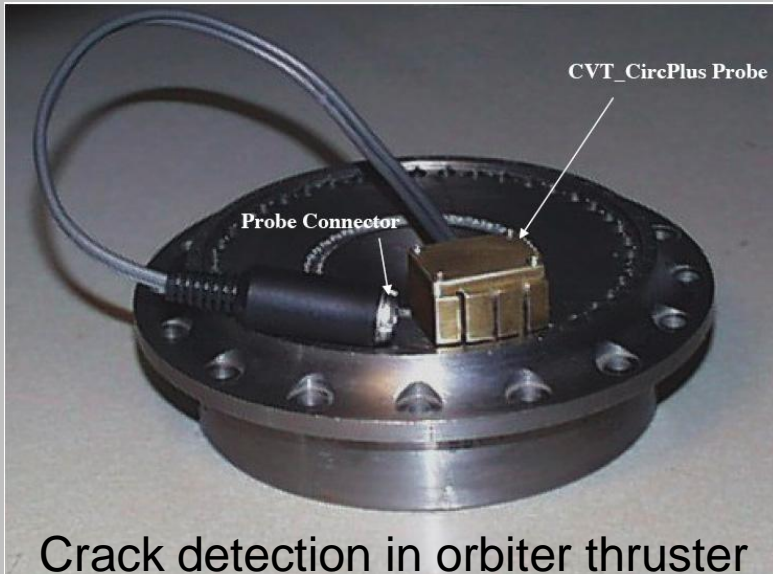
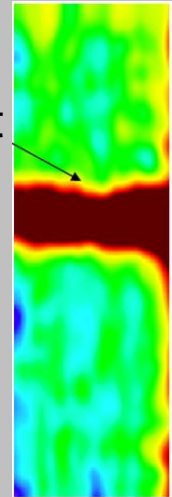
Signal from undamaged site

Advanced Eddy Current

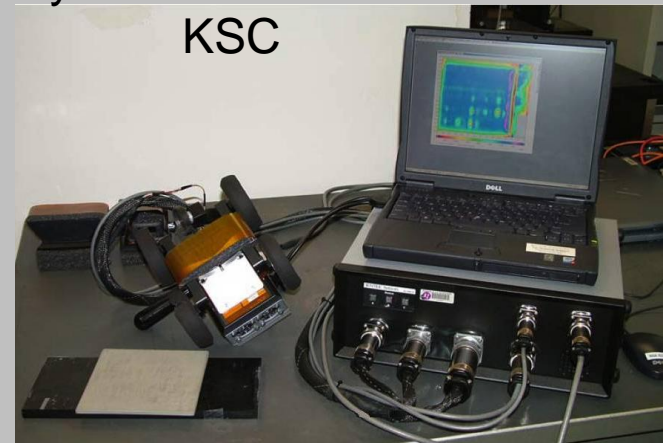


Rotating Self-nulling
Probe

Eddy current
system
detecting
crack in
RCC test
specimen



Advanced eddy current
system delivered to
KSC



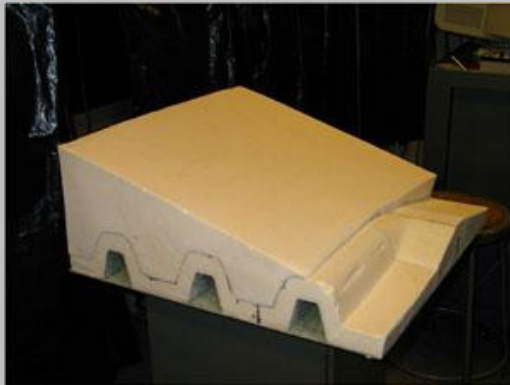
Terahertz Imaging of Flaws in Foam on the External Tank



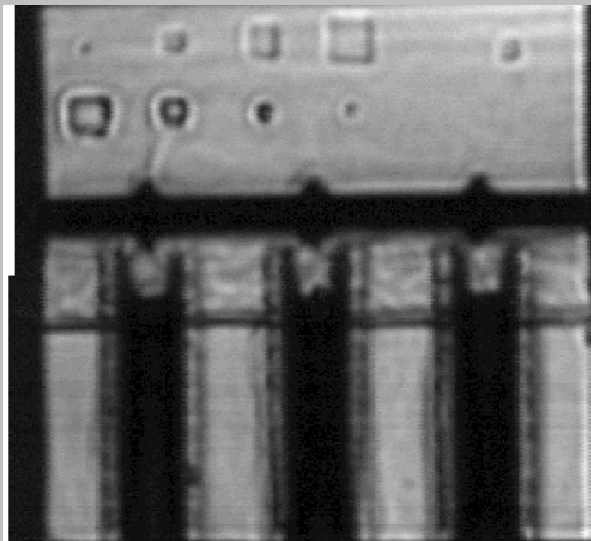
Implementation of a terahertz imaging system for detecting flaws in the external tank's foam



SOFI on the external tank near the intertank regions



PAL ramp SOFI test panel



Terahertz image from a SOFI test panel

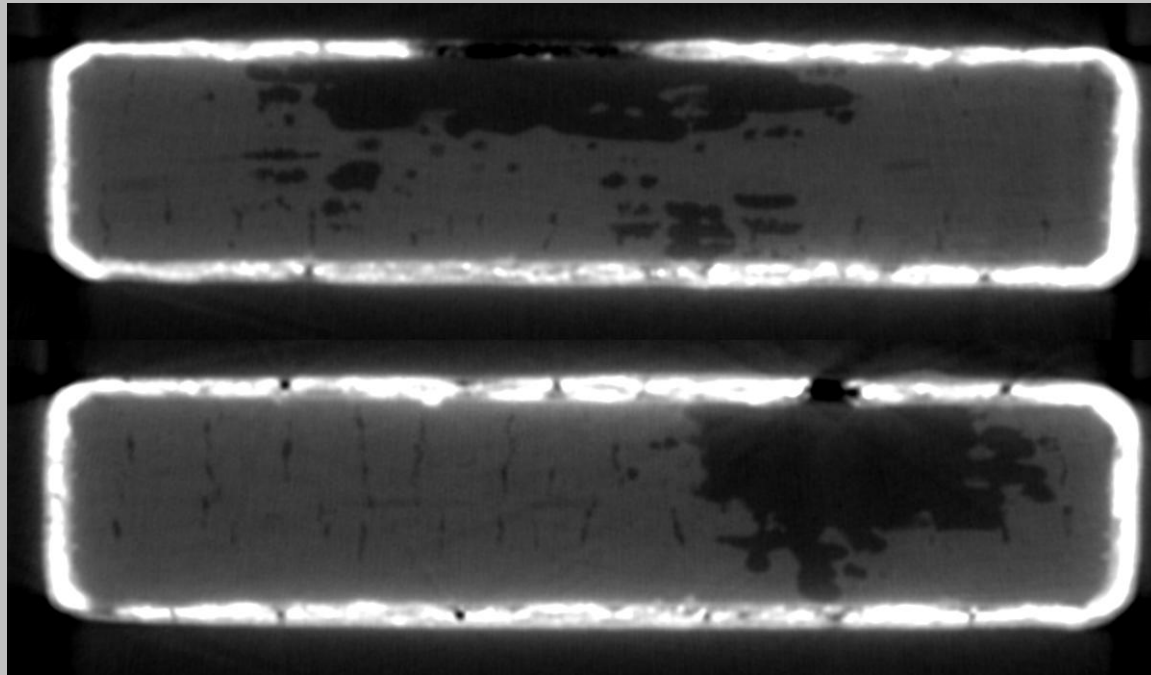


System implemented at Michoud for PAL ramp inspection

NDE for Hypersonics



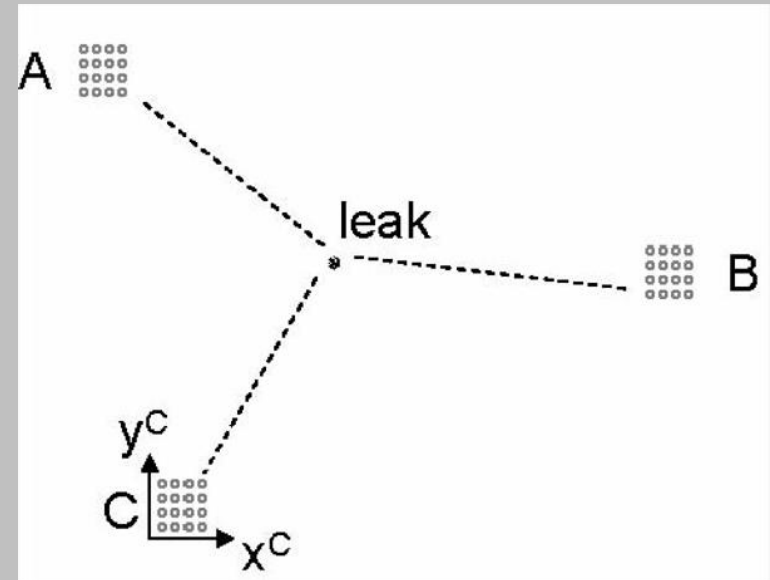
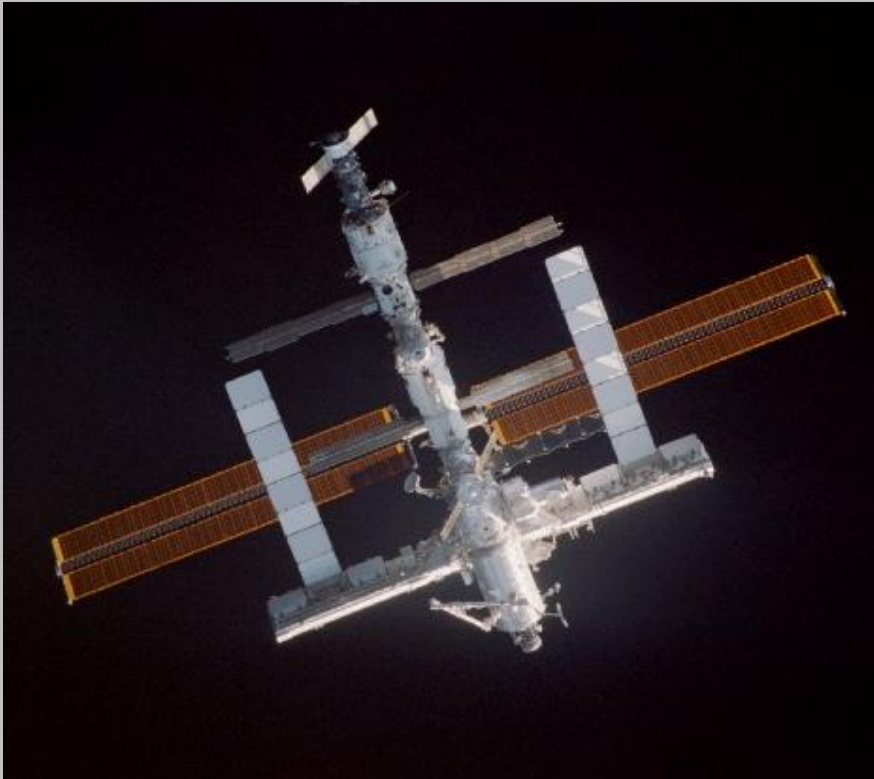
Perform eddy current, microfocus CT and thermography of RCC specimens



Microfocus CT images of internal oxidation
of RCC

Space Operations

International Space Station



Ultrasonic arrays for leak
location based on structure
borne ultrasonic noise

Collaboration with Stephen Holland and Dale Chimenti
Center for Nondestructive Evaluation, Iowa State University

Summary



- >25 years R&D of a Broad Range of NDE Technologies for Advanced Aerospace Applications
- Proof of Concept - Field - Integrated NDE Systems